New Series No. 263 November 15, 1933

UNIVERSITY OF IOWA STUDIES

STUDIES IN NATURAL HISTORY

Volume XV Number 4

Sedimentation in Red River Below the Mouth of Washita River

by

VICTOR H. JONES, Ph.D.

Published by the University, Iowa City, Iowa

Issued semi-monthly throughout the year. Entered at the post office at Iowa City, Iowa as second class matter under the Act of October 3, 1917.

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University of Iowa Studies in Natural History

HENRY FREDERICK WICKHAM, Editor

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INTRODUCTION

This paper is a report on one unit of a general study of Mississippi River and its major tributaries as agents of sedimentation. Other units have been reported previously.[1]

General Features of the Region

The key map, Figure 1, shows the extent of the lower Red River region.

The lower Red River flows through the Gulf Coastal plain which lies between sea level and 600 feet above sea level. The relief is comparatively small and is due chiefly to the dissection by streams of a gently sloping plain. Two subdivisions of this plain are apparent: (1) hilly regions, and (2) flood-plain and terrace areas.

The hilly regions are composed of Cretaceous and Tertiary sediments. The hills stand from 100 to 200 feet above the river valleys. The stream drainage pattern in general is dendritic, but a series of low ridges or cuestas has resulted from the differential erosion of stratified, sedimentary rock formations. These ridges, except the northernmost, extend approximately northeast-southwest across the Red River valley and are known, from south to north, by the following names: Kisatchie Wold, Sulphur Wold, Saratoga Wold, and Lockesburg Wold.[2] They are formed by the outcropping edges

[1] Trowbridge, A. C.—Sedimentation at the Mouths of the Mississippi River —preliminary report (abstract): Geol. Soc. Am. Bull., vol. 34, p. 95, 1923; Disposal of Sediments Carried to the Gulf of Mexico by Southwest Pass, Mississippi River (abstract): Geol. Soc. Am. Bull., vol. 36, pp. 164-165, 1925; Building of Mississippi Delta. Amer. Assoc. Petroleum Geologists Bull., vol. 14, pp. 867-901, July, 1930.

Lugn, A. L.—Sedimentation in the Mississippi River Between Davenport, Iowa and Cairo, Illinois. Augustana Library Publications No. 11, Rock Island, Ill., 1927.

Littlefield, Max S.—Mississippi Gravels Below the Mouth of the Arkansas River (abst.): Geol. Soc. Am. Bull., vol. 38, p. 147, 1927.

Jones, Victor H.—Contribution of Sediments to the Mississippi Delta by Red River (abst.): Geol. Soc. Am. Bull., vol. 41, p. 165, 1930.

[2] Veatch, A. C.—Geology and Underground Water Resources of Northern Louisiana and Southern Arkansas. U. S. Geol. Survey. Prof. Paper No. 46, pp. 14-16, 1906.

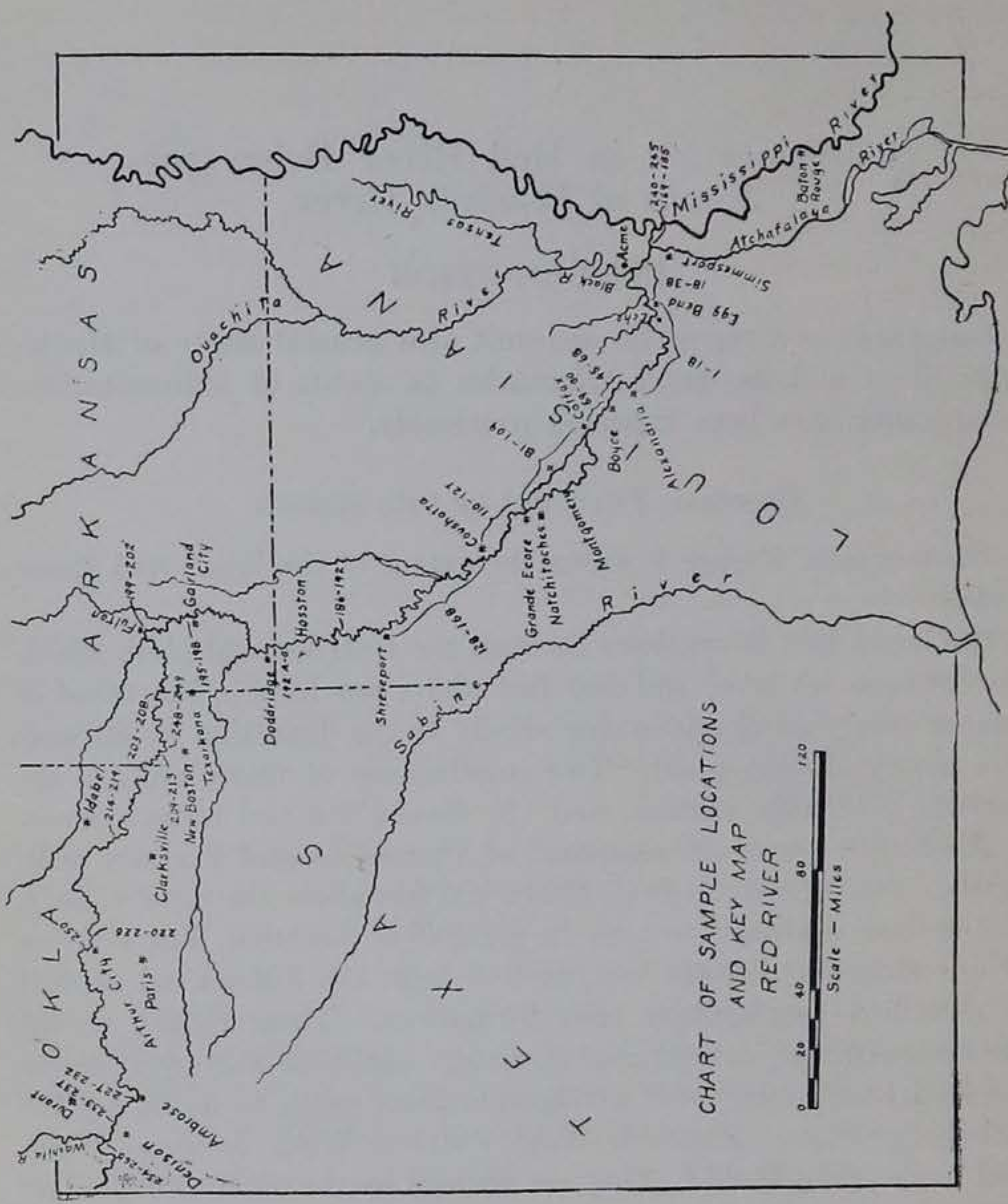

Figure 1.

of the Catahoula (Miocene), the Wilcox (Eocene), and the Sabine and Nacatoch (Upper Cretaceous) formations respectively.

The stream valleys are filled with terrace deposits and alluvial material of Pleistocene and recent origin. One feature of the Red River flood-plain has become much less prominent during the past century. This was a series of lakes in the main valley and in the lower portions of many small tributaries, which were produced by extensive log rafts or dams.[3] At one time the obstructions blocked

[3] Veatch, A. C.—Idem., pp. 60-62.

the main channel of Red River almost completely from Shreveport to Natchitoches. Since the raft has been blasted away the lakes have been gradually disappearing as the rivers have resumed their normal courses. When boat traffic was important, Natchitoches owed its prominence to its location at the head of navigation on Red River. The river has since changed its course to a channel about 4 miles east of the town.

The average rainfall of the Three Rivers Region at the mouth of Red River is approximately 60 inches per year, and in the vicinity of Denison it is about 32 inches annually. Intermediate points have precipitation ranging between the two extremes.

In order to understand the sources for Red River sediments the rock formations which crop out along the river and near it must be considered. Detailed and quantitative information concerning the minerals in these formations is available only for a few exposures. Therefore as many outcrops as possible were studied and sampled in the course of the field work for this report. The rocks of the region range in age from Lower Cretaceous to Recent, and all are sedimentary. Table I is a generalized chart of the formations, and shows approximate average thicknesses.

From the Trinity sandstone, which is exposed near the confluence with Washita River, the Red River Valley traverses the younger formations of the Gulf Region until it joins the vast alluvial, Mississippi River plain near Marksville, Louisiana. The great bulk of the material in these formations was derived from pre-existing sedimentary rocks, and therefore may be regarded as reworked material. The Cretaceous and Tertiary formations of the region contain nearly all the common varieties of sedimentary rocks, and they give certain prominent characteristics to the Red River sediments. The red color, which is usually bright, is immediately noticeable. The coloring matter is obtained partly from the Permian and Pennsylvanian rocks farther west, but the volume of ferruginous sediment is greatly augmented in Louisiana by the addition of iron oxides from various Tertiary formations which contain considerable quantities of iron-bearing minerals such as glauconite, limonite, hematite, magnetite, and ilmenite. Ferruginous concretions are abundant in several strata of the Tertiary section. The high mica content of the Midway silts, sands, and clays is notable, and their color is typically lighter than that of the later Tertiary groups.

Table I

STRATIFIED FORMATIONS OF THE LOWER RED RIVER REGION

(Compiled)

System	*Series*	*Group—Formation*	*Lithologic Character*	*Approximate Thickness* (feet)
Quaternary	Recent Pleistocene	Port Hudson	Alluvium: gravels, sands, clays Gravels, sands, terrace deposits	
Tertiary	Pliocene	Citronelle	Fluvial sand, gravel, some clay	200
	Miocene	Catahoula	Sand, ss., and clay	500
	Oligocene	Vicksburg group	Not at surface in NW La.	
	Eocene	Jackson group	Sands, clays, some glauconite	500
		Claiborne group	Alternating sands and clays, some micaceous, glauconitic, lignitic, or ferruginous	1000
		Wilcox group	Lignitic sands, clays; ferruginous ss. with limonite concretions	700
		Midway group	Mainly clays with some sand, glauconite, thin limestone beds, and mica	400

Cretaceous	Upper	Arkadelphia		Chiefly clays	600
		Nacatoch		White and brown sand	135
		Marlbrook		Marl, thin-bedded limestone, and clay	145
		Anona		Chalk and calcareous clay	460
		Brownstown		Marl	100
		Bingen Eagle Ford Woodbine		Sand	300
				Sand	200
	Lower	Washita	Denison	Limestone and calcareous shale	175
			Fort Worth	Limestone and shale	150
			Preston Duck Creek Kiamitia	Limestone	100
				Clay and shale	250
		Fredericksburg	Goodland	Limestone	150
			Walnut	Clay and marl	150
		Trinity	Paluxy	Sand, sandstone	150
			Glen Rose	Sand and shale	150

The conglomerates and gravels of the region are predominantly chert, quartz, and iron oxides. The texture of the clastic sediments is relatively fine. Except for concretions, chiefly calcareous and ferruginous, pieces of cobble size are rare. Information concerning the stratigraphy and structure of the lower Red River Region has been obtained especially from the sources cited below.[4]

The structure of the region is dominated by the Sabine uplift, a broad, low dome with a northwest-southeast axis. It occupies a large area in northeastern Texas and northwestern Louisiana and adjacent portions of Oklahoma and Arkansas. Although the quaquaversal dips have low angles, from a fraction of a degree to a maximum of 6 degrees, the dome is the dominant structure over an area of approximately 19,000 square miles. The river, which flows in a southeasterly direction across the center of the uplift, crosses the Tertiary formations on its north flank in southwestern Arkansas, and traverses the same formations in the reverse order on the south flank in central Louisiana. Southeast from Grande Ecore the dip decreases gradually toward the Gulf of Mexico.

Methods

The river was sampled and studied during the field season of 1928 and during the last half of March, 1930. The entire channel below Shreveport was studied with the aid of a 16 foot boat equipped with an outboard motor, and samples were obtained by means of a sliding sleeve sampler designed by Lugn.[5] Above Shreveport the river was studied at as many points as were accessible by automobile in the time available. Sample locations are indicated by number in Figure 1. Samples of sediments were taken

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[4] Matson, G. C., and Hopkins, O. B.—The De Soto-Red River Oil and Gas Field, Louisiana: U. S. Geol. Surv. Bull. 619, pp. 109-112, 1916.

Hammill, C. A.—The Cretaceous of Northwestern Louisiana: Bull. Amer. Asso. Petroleum Geologists, vol. 5, pp. 298-310, 1921.

Honess, C. W.—Atoka, Pushmataha, McCurtain, Bryan, and Choctaw Counties, Oklahoma: Oklahoma Geol. Surv. Bull. 40-R, 1927.

Matson, G. C.—The Caddo Oil and Gas Field of Louisiana and Texas: U. S. Geol. Surv. Bull. 620, pp. 1-35, 1916; The Pliocene Citronelle Formation of the Gulf Coastal Plain: U. S. Geol. Surv. Prof. Paper 98, pp. 167-192, 1916; The Catahoula Sandstone: Idem. pp. 209-226.

Moody, C. L.—The Tertiary History of the Region of the Sabine Uplift of Louisiana: Bull. Amer. Assoc. Petroleum Geologists, vol. 15, pp. 531-551, 1931.

[5] Lugn, A. L.—Methods of Taking Sediment Samples from the Mississippi River. Iowa Univ. Studies, new ser., No. 104, Studies in Natural History, vol. 11, pp. 23-31, 1926.

from the channel, chutes or secondary channels, bars, banks, and outcrops of bedrock along the valley. The majority of the channel samples were taken in sections or series across the stream approximately at right angles to the channel. Depth of water and approximate current speed were noted at points where samples were obtained.

The samples were dried in the laboratory and separated into size grades by elutriation and seiving according to the millimeter scale of Wentworth.[6] Subsequent study of the mineral grains was conducted by means of binocular and petrographic microscopes, and the data tabulated on appropriate cards. The scale of roundness used is that of Tester,[7] which is indicated below:

R—Well-rounded
C—Curvilinear
r—Sub-round
a—Subangular
A—Angular

Description of the Samples

Introduction

Most of the samples were obtained while traveling upstream during July, August, and early September of 1928. During that period the stage of water was almost continually falling after the unusual high stage of early July. As an illustration of this condition on the whole river the following gage readings from the St. Louis and Southwestern Railroad bridge at Garland City, Arkansas are typical.[8]

Day	July	August	September
6	14.2	11.4	5.8
12	9.7	9.5	5.8
20	10.8	7.0	5.1
25	9.0	6.8	4.9
30	11.0	6.1	4.8

In the descriptions of samples and features along the river the

[6] Wentworth, C. K.—Methods of Mechanical Analysis. Univ. of Iowa Studies in Natural History, vol. 11, No. 11, 1926.

[7] Tester, A. C.—The Measurement of the Shapes of Rock Particles. Jour. Sedimentary Petrology, vol. 1, pp. 3-11, 1931.

[8] Frame, W. S.—Stream Gaging in Arkansas from 1851 to 1928. Arkansas Geol. Surv. Gaging Report 1, pp. 102-103, 1930.

banks are mentioned as *right* or *left*, the respective sides as one faces downstream. The terminology used in the descriptions and interpretations of the mechanical analyses is that of Udden[9] and Wentworth.[10] Although 265 samples were collected and studied, only a few of them can be described in this brief report. The *heavy minerals* are those having a specific gravity greater than 2.87, and were separated in bromoform.

Samples from Red River Between the Junction with Washita River and Texarkana

Sources of river sediments at and near the junction with Washita River are the sandy Lower Cretaceous Washita formation, terrace deposits, and sands and silts of the present flood-plain. On March 28, 1930, a 15 foot thickness of the Washita limestone was being actively eroded on the left bank of Red River 1/4 mile above the mouth of the Washita. The water of the tributary was clear, and its current no swifter than 1 mile per hour. It could be distinguished sharply from the red water of the main stream as the two joined. Although the Washita drains hilly areas, its contribution to the load of the main stream is insignificant except during seasons of high water. The bottoms of both rivers are covered with alluvial sands and silts which are probably thin.

Analysis graphs of typical sediments from this locality are shown in Figure 2 (See also fig. 1). *Number 255* represents the coarsest material in the river, and it contains one subangular quartz pebble in the 4-2 mm. grade. It was taken from mid-channel where the depth was 3 feet 1/3 mile above the mouth of Washita River. Its heavy mineral content is as follows:

Biotite	11.0%	Corundum	10.0%
Hematite	20.0%	Zoisite	10.0%
Limonite	20.0%	Black opaques	29.0%

Sample 257 is typical of the finest sediment from the bottom of Red River at the same location, and is a sandy silt. Brown chert and iron oxides are responsible for its deeper red color. *Sample 261* represents the Washita River sediments 1/3 mile above the mouth, and is finer than the finest of the nearby Red River channel

[9] Udden, J. A.—The Mechanical Composition of Clastic Sediments. Bull. Geol. Soc. America, vol. 25, pp. 655-744, 1914.

[10] Op. cit., p. 24.

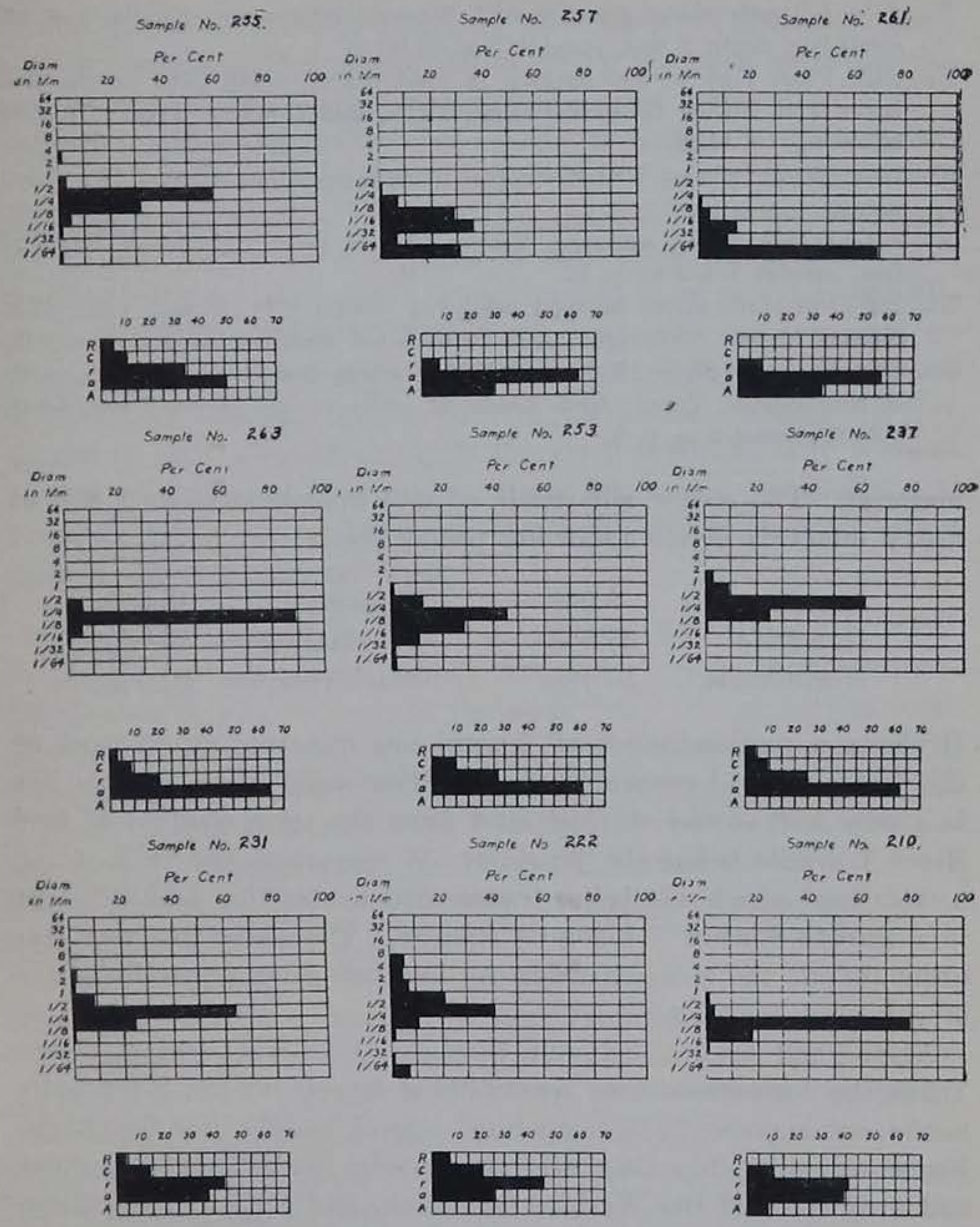

Figure 2. Analysis graphs of sediments from Red River between the mouth of Washita River and Texarkana.

LOCATIONS OF SAMPLES SHOWN IN FIGURE 2

No. 263—1/8 mile below junction with Washita River; 20 feet from left bank, depth 2 feet, current 1 1/2 m. p. h.

No. 261—From Washita River 1/8 mile above its mouth; 20 feet from left bank, depth 7 feet, current 1 1/2 m. p. h.

No. 257—1/3 mile above junction with Washita River; 12 feet above water, left bank.

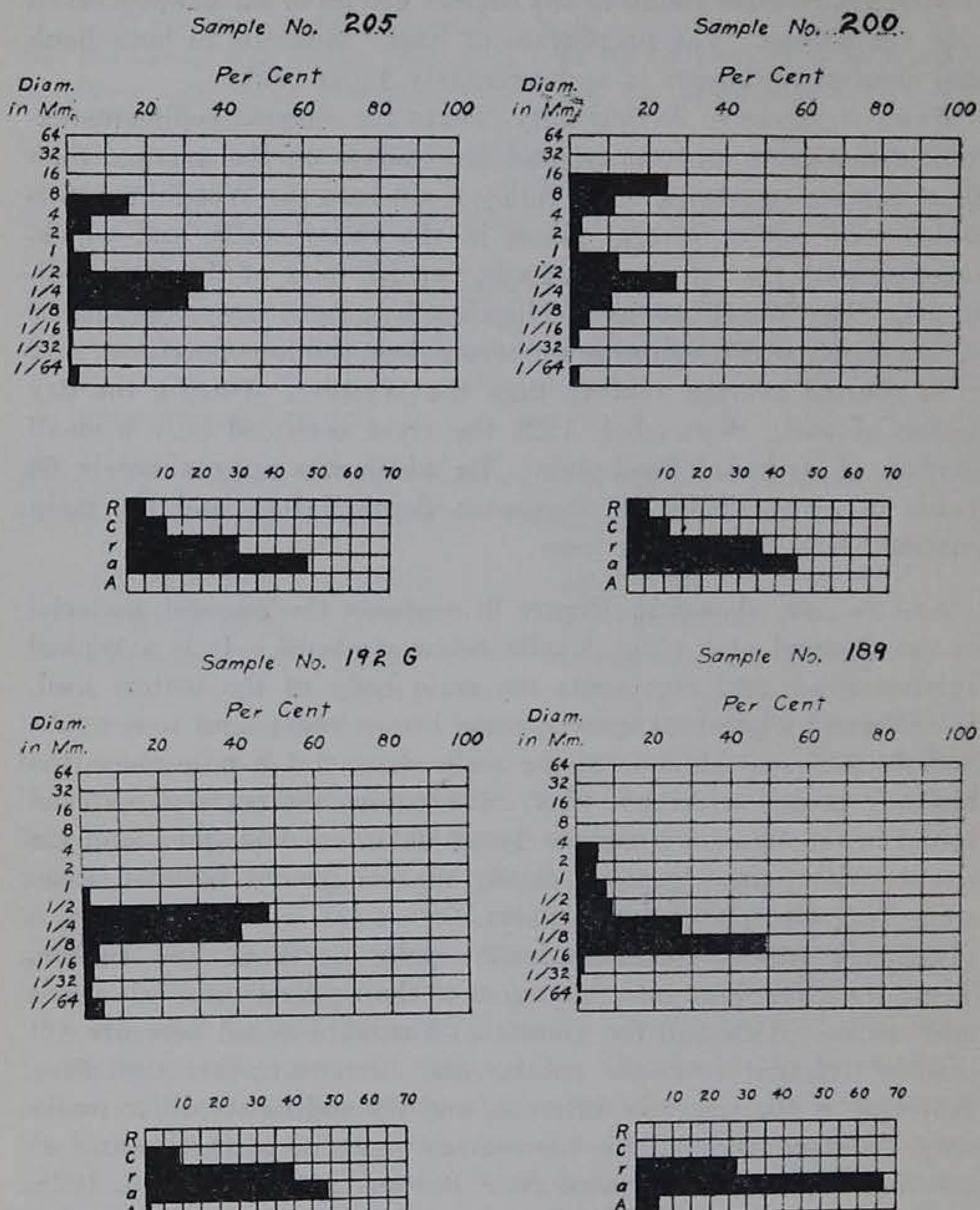

Figure 3. Analysis graphs of sediments from Red River between Index, Arkansas and Shreveport, Louisiana.

LOCATIONS OF SAMPLES SHOWN IN FIGURE 3

No. 205—1/2 mile below Index, Ark. (10 miles north of Texarkana); from top of submerged bar in midstream, depth 2 1/2 feet, current 3 m. p. h.

No. 200—50 yards below the ferry across Red River at Fulton, Arkansas; 50 feet from right bank, depth 2 1/2 feet, current 2 m. p. h.

No. 192G—Upper Claiborne sand from a cut of the Kansas City and Southern Railroad; 1 mile northeast of Vivian, La.

No. 189—1/2 mile above Sentell Landing (13.4 miles north of Shreveport, La.); 70 feet from right bank, depth 2 feet, current 2 1/2 m. p. h.

Sediments from Red River Between Index, Arkansas and Shreveport, Louisiana. (Fig. 1)

The Red River valley in southwestern Arkansas contains great quantities of Port Hudson terrace silts and gravels. It is about 10 miles wide on the average, and is crossed obliquely near Fulton by the Saratoga Wold, a low ridge caused by the outcropping edge of the Nacatoch sand and gravel. In harmony with the coarser sediments exposed along the banks the channel sediments are coarser than those anywhere upstream as far as the Washita. All but the coarsest material available was subject to transportation by the current which flowed at a speed of 4 miles per hour in many places. The presence of pebbles up to 8 mm. in diameter resulted in their accumulation in the main channel to form lag deposits in a few places. The mechanical analysis graphs of *Samples 200 and 205,* shown in Figure 3, represent the lag deposits, and show that pebbles are fairly common in the channel in some parts of this stretch. *Number 205* was taken from a shallow portion of the main channel in swift current 1/2 mile below Index, Arkansas (10 miles north of Texarkana). *Number 200* was obtained in the main channel at Fulton. The common type of well sorted channel sands from this stretch are composed chiefly of medium or coarse sand grains. They contain about 95 per cent quartz, and usually some grains of chert, muscovite, iron oxide, and nodular calcite.

In the northwestern corner of Louisiana the Red River Valley is cut into the Claiborne formation which consists chiefly of ferruginous sands and shales. Hematite and limonite concretions are abundant in it, and much of the argillaceous material becomes red or brown when weathered. *Sample 192 G,* from a friable zone in the Claiborne near Vivian, is similar in size grade distribution, shape of grain, and in heavy mineral content to many of the river sands.

A feature of the channel at Sentell Landing, Louisiana (13.5 miles north of Shreveport) on September 3, 1928 was a great number of well developed sand waves which covered a large portion of the flood plain and about one-half of the channel on a straight reach. They bear some resemblance to large current ripple marks, but form at an angle of approximately 45 degrees to the current instead of normal to it. Some of them have unbroken crests extending for 50 feet or more, and they are formed in the swift current of the channel where the maximum sized particles are being transported. At Sentell Landing they had an average distance of three feet from crest to crest and a height of 2 1/2 to 3 1/2 inches. Their ripple index was from 10 to 14. Pebbles were being slowly rolled up the long slopes and then dropped abruptly into the intervening troughs where they accumulated in the lee of the wave crests. The waves were migrating with the current. *Sample 189,* shown in Figure 3, represents the material from the sand wave troughs.

Sediments from Red River Between Shreveport and Coushatta, Louisiana (Fig. 1)

The samples from this stretch were taken while traveling upstream by boat August 22 to 26, 1928, during which time the stage of water was falling from 1 to 3 inches or more daily. The valley has an approximate width of 7 miles and in many places shows the effect of ponding by the old log rafts. So tortuous is the channel between the two cities that its length is nearly 80 miles although the air line distance is 43 miles. The average gradient of the stream bed on this stretch is less than 6 inches per mile.[11] For a large portion of the distance the stream is confined between artificial levees. The country rock for nearly the whole distance between Shreveport and Coushatta is the Wilcox which has a broad area of outcrop near the center of the Sabine uplift. Because of vegetation, alluvium, and the well developed Port Hudson terraces, however, the Wilcox crops out at only a few places along the river.

Analysis graphs of typical samples from the Shreveport-Coushatta stretch are shown in Figure 4. *Numbers 164 and 148* represent the coarsest sediments found in the channel of Red River, and were obtained in parts of the channel which were constricted and in which the current was unusually swift. Such places occur commonly during seasons of falling water stage when the current is confined to the lowest portions of the bed. Current speeds of 5 and 6 miles per hour were observed in a few places. The secondary maximum in the distant coarse grade indicates a similarity to a

[11] Calculated from data in Surface Water Supply of the United States, Part VII, U. S. Geol. Survey Water Supply Paper 667, 1928.

lag deposit, but these two samples are not true lag sediments because even the coarsest ingredients were being rolled and shoved by the current. They were formed not by selective action by the current, but as a result of the type of material available to it. They

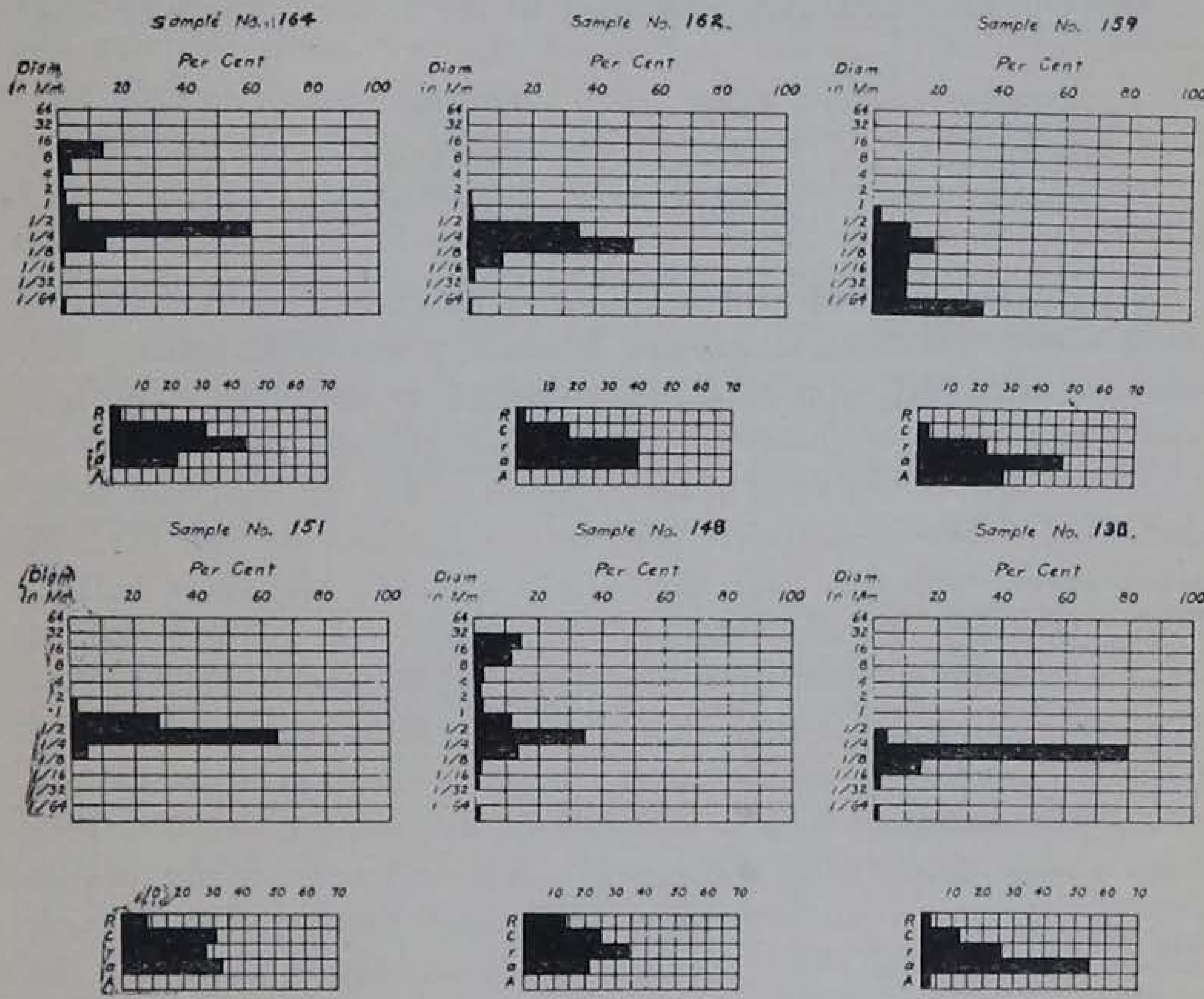

Figure 4. Analysis graphs of sediments from Red River between Shreveport and Coushatta, Louisiana.

Locations of Samples Shown in Figure 4

No. 164—20 miles below Shreveport; surface of bar 1 foot above water.

No. 162—22 miles below Shreveport at a bend; 40 feet from right bank, depth 13 feet, current 3 m. p. h.

No. 159—31 miles below Shreveport; middle of chute on right of bar, depth 4 feet, current 1 m. p. h.

No. 151—40 1/2 miles below Shreveport; 30 feet from left bank, depth 2 feet, current 4 m. p. h.

No. 148—48 miles below Shreveport; midstream off lower end of a bar, depth 3 feet, current 6 m. p. h.

No. 138—4 miles above Coushatta; midstream, depth 5 feet, current 5 m. p. h.

resemble the pudding sand mentioned by Lugn[12] in Mississippi River and are rare in Red River. Many of the pebbles are composed of clay or lignite. The bulk of the sediment at the bend 20 miles below Shreveport, where *Number 164* was obtained, was medium and fine sand similar to that of *Sample 162*. The heavy minerals in the fine admixture of *Sample 162* amount to 80 per cent of the separate, and were identified in the following proportions:

Biotite	2.0%	Titanite	5.0%
Leucoxene	3.0%	Tourmaline	3.0%
Rutile	2.0%	Black opaques	85.0%

Sample 159 is a silt from a chute or secondary channel 60 feet wide and 2 feet deep at a point 30 miles below Shreveport. The current in it had been markedly retarded as the river stage fell, and the 1 mile per hour rate of August 25 was incompetent to transport any of the sand grades. Much of the silt load was being deposited. The prominent secondary maximum of the medium sand grade indicates that this grade was the abundant bottom load a few days before. *Number 159,* therefore is a silted channel sand or chute deposit resulting from decreasing current. This type of silty sand has been deposited over wide areas of the flood plain during falling water stages. Upon dessication it cracks into polygonal pieces up to a few inches in diameter, splits into thin layers, and warps with the concave side upward. Many of the pieces continue to curl until the edges meet and a roll is formed. When hundreds of these sediment curls are blown about by the wind they produce a dry, rattling sound similar to that of dried leaves.

Sample 151 is a typical, well sorted channel sand from a straight reach in the channel 40 miles below Shreveport. Its high proportion of well rounded and frosted grains indicates that wind action has been efficacious at some former time and that much of the material has been through more than one period of sedimentation. It consists almost entirely of quartz grains. Most of the channel sands from the locality are similar to it.

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[12] Lugn, A. L.—Sedimentation in the Mississippi River Between Davenport, Iowa, and Cairo, Illinois: Augustana Library Publications No. 11, p. 97, Rock Island, Illinois, 1927.

Sediments from Red River Between Coushatta and Alexandria

From Coushatta to Grande Ecore the distance by river is nearly 40 miles, and the channel is near the left side of the valley for the entire distance. The valley width from bluff to bluff is about 7 miles, and the east bluff is bordered almost continuously by the terrace deposits. Although the Midway formation is the country rock, outcrops along the river are rare, and the Wilcox crops out in the bluff at Grande Ecore.

A relative uniformity in texture characterizes the channel sediments between Coushatta and Grande Ecore, and they show a marked contrast to the coarser, pebbly sands of the Shreveport-Coushatta stretch. The coarsest material found in the river between Coushatta and Grande Ecore was a sand containing 5 per cent of pebbles 4-2 mm. in diameter. The analysis graphs of this sample, *Number 115*, from the channel 3 1/2 miles above Grande Ecore, are shown in Figure 5. In it the following heavy minerals were identified:

Anatase	10.0%	Magnetite	25.0%
Hornblende	15.0%	Ilmenite	30.0%
Rutile	20.0%		

Number 124 is a typical, well sorted sand from the channel 10 miles above Grand Ecore. These sands contain 90 per cent quartz on the average, and the principal accessory minerals are chert, limonite, and black opaque minerals. They have a higher degree of angularity than the sands from any other portion of the river.

At Grande Ecore the river is flowing on a tough, black shale which forms the base of the Wilcox outcrop in the 175 foot bluff. *Sample 111,* represented in Figure 5, is a 6 foot, vertical section of a fine, friable, reddish sand from this outcrop. The peculiar form of the mechanical analysis graph is the result of sampling across thin beds of well sorted sand and silt. The sediments from this outcrop contain from 85 to 95 per cent quartz; and lignite, iron oxides, and muscovite are the most abundant accessory minerals. Smoothed and polished chert pebbles up to 64 mm. in diameter were found on the top of the bluff. They are probably remnants of an older high terrace deposit.

From Grande Ecore to Colfax, a distance of approximately 40 miles by water, the river flows close to the left side of its valley.

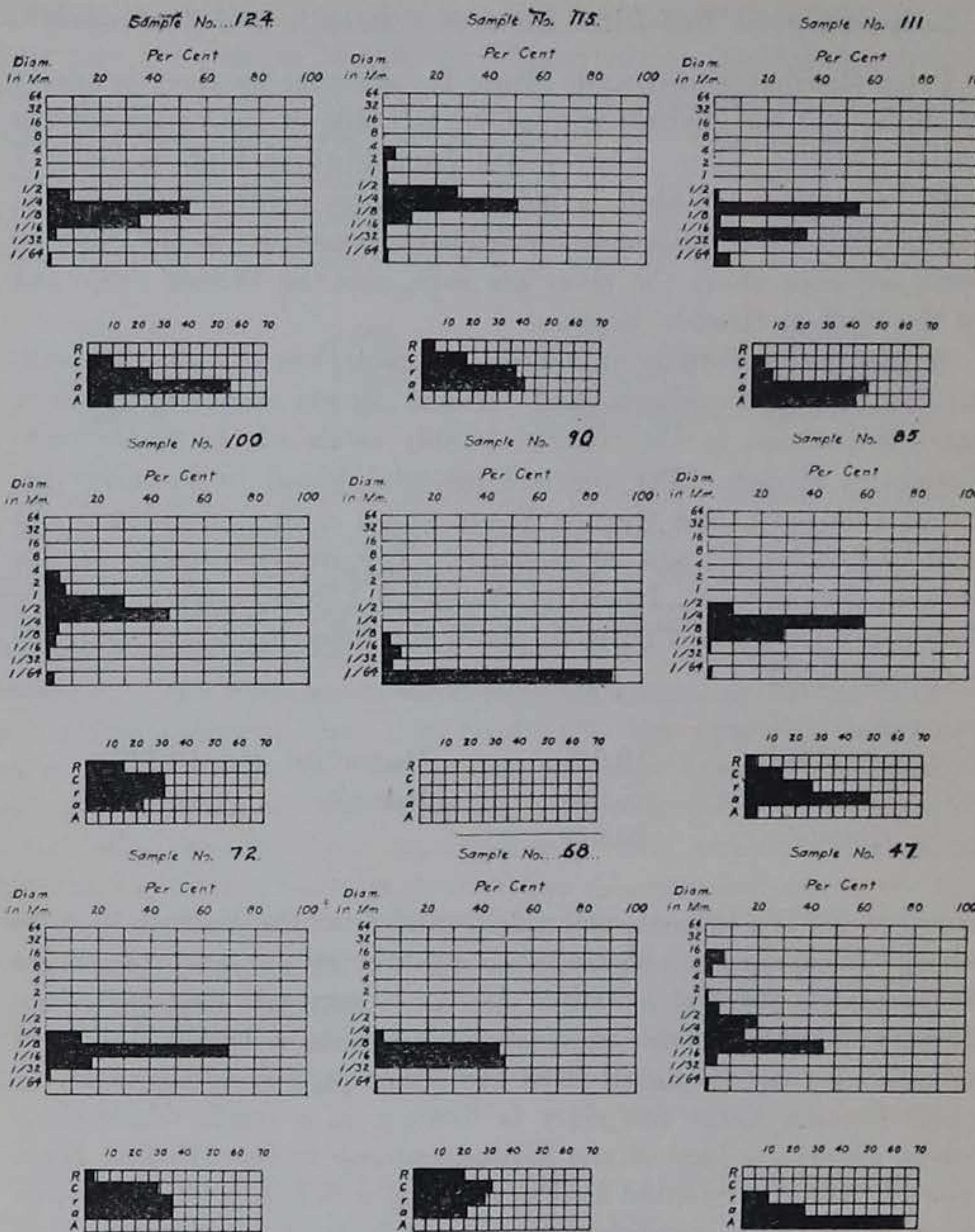

Figure 5. Analysis graphs of sediments from Red River between Coushatta and Alexandria, Louisiana.

LOCATIONS OF SAMPLES SHOWN IN FIGURE 5

No. 124—10 miles above Grande Ecore at middle of a bend; 40 feet from left bank in main channel, depth 9 feet, current 4 m. p. h.

No. 115—3 1/2 miles above Grande Ecore at a bend; 30 feet from left bank in main channel, depth 10 feet, current 3 m. p. h.

No. 111—From the outcrop of The Wilcox formation in the bluff at Grande Ecore, 80 feet from top.

No. 100—8 miles above Montgomery; midstream just above a bend, depth 6 feet, current 4 m. p. h.
No. 90—Opposite outcrop of Jackson strata in the bluff 5 miles below Montgomery; 60 feet from left bank, depth 8 feet, current 2 m. p. h.
No. 85—8 miles above Colfax; midstream at a bend, depth 9 feet, current 4 m. p. h.
No. 72—5 miles above Boyce; midstream, depth 6 feet, current 4 m. p. h.
No. 68—21 miles above Alexandria; midstream, depth 6 feet, current 4 m. p. h.
No. 47—2 miles above Alexandria; 50 feet from right bank, depth 8 feet, current 3 m. p. h.

The outcropping edges of the Claiborne and Jackson formations are actually visible in only a few places because of alluvium and slumped material. Their narrow bands of outcrop are due to the relatively steep dip on the Angelina-Caldwell monocline, a minor flexure on the south flank of the Sabine uplift.[13] The terrace deposits occur at only a few places on this part of the river. The greater part of the main channel sediments in Red River, therefore, are derived from the deposits of the flood-plain and from outcrops of Upper Eocene formations along the left side of the valley. Very little material coarser than sand was found in any of these. The analysis graphs of *Samples 100, 90, and 85,* shown in Figure 5, indicate the fineness of the river sediments also. *Number 100* is the coarsest sample from this stretch of the river. It was obtained in mid-channel 8 miles above Montgomery where the stream flows over a resistant bed of dark blue shale, one of the spurs of bedrock now being eroded as a result of channel changes incident to the destruction of the great raft. The coarse grades of this sample are chiefly black carbonaceous shale fragments and clay pebbles.

An outcrop of fossiliferous Jackson 5 miles below Montgomery consists chiefly of fine sands, silts, and clays containing various amounts of iron oxides, partly in the form of concretions. This locality is one of several where clay pebbles were being formed in considerable quantity by the erosion of black shale at the foot of the bluff. The term "clay pebbles" is used here to mean fragments of clay or shale which have been worn into rounded shapes by the river current. They are common in the Red River sediments and originate in two ways. When the current erodes a bank de-

[13] Moody, C. L.—Tertiary History of the Region of the Sabine Uplift of Louisiana. Amer. Assoc. Petroleum Geologists Bull., vol. 15, p. 549, 1931.

posit or older terrace containing previously formed clay pebbles, they are incorporated in the channel deposits. At the Jackson outcrop near Montgomery and at several other places the pebbles were observed in the process of formation where the river was eroding a shale outcrop. When chunks of shale fall into the stream some of them resist soaking and disruption for a few days or weeks. They may be perfectly rounded by abrasion, and may become studded with small quartz or chert pebbles.

Sample 90 was gouged from the firm clay bottom in the river channel near the outcrop. *Sample 85* represents the most common type of channel sand between Grande Ecore and Colfax.

Between Colfax and Alexandria the valley is cut into the relatively resistant Catahoula sandstone, and is markedly constricted. The Catahoula consists largely of fine sands and silts containing many frosted and pitted grains. Accessory minerals identified in samples from the formation are hematite, muscovite, chert, woody material, pyrite, zircon, and black opaque minerals. *Sample 72* is typical of the fine and very fine sands from this reach of the river. It contains 3 per cent of heavy minerals in the following proportions:

Biotite	5.0%	Hornblende	15.0%
Pyrite	5.0%	Zircon	15.0%
Hematite	30.0%	Black opaques	30.0%

Sample 47, from the main channel 2 miles above Alexandria, contains the coarsest material from this stretch. All the pebbles in it are brown chert, and the sand grades contain many pitted and frosted grains. Accessory minerals in the sand grades are glauconite, zircon, pyrite, and hematite. *Sample 68* is a concentrate of heavy minerals or placer type deposit from the channel just below Boyce. It contains 94 per cent of minerals having a specific gravity greater than 2.87, in the following proportions:

Hematite	10.0%	Magnetite	30.0%
Tourmaline	5.0%	Ilmenite	40.0%
Zircon	5.0%	Glauconite	6.0%
Rutile	4.0%		

The deep color of the river and its sediments is maintained and augmented on this stretch by contributions from the ferruginous terrace deposits and oxidized material from the Catahoula.

Sediments from Red River Between Alexandria and the Mouth of Black River

The broad valley below Alexandria is bordered by low bluffs of Pleistocene sands, gravels, and silts for about 60 miles to a point opposite Marksville. From these east-facing bluffs the stream enters the great flood-plain of the Mississippi Valley. The samples from the lower river were obtained during July when the water was at a higher stage than in August and September when the upper river was sampled. Much greater turbulence and the presence of eddies on the insides of bends characterized this stretch. The silt content of the water was relatively large and the water was a deeper red color than it was a month later. At many places the rising water was cutting deeply into bank and bar deposits in and along the channel.

Sample 1 (fig. 6), which contains 4 per cent of 4-2 mm. pebbles, is the coarsest material found in the channel below Alexandria. It was obtained in mid-stream 1/2 mile below the city. The fine admixture contained 3 per cent of heavy minerals in the following proportions:

Anatase	5.0%	Zircon	5.0%
Topaz	5.0%	Magnetite	30.0%
Tourmaline	25.0%	Ilmenite	30.0%

Three miles below Alexandria the river was eroding the base of a 60 foot bluff. The largest pieces in the outcrop were pebbles about 64 mm. in diameter. A sample collected to show maximum sized material contained 80 per cent chert, 15 per cent limestone, 4 per cent dark, dense, igneous rock, and 1 per cent iron oxide. The bluff is probably the remnant of a Port Hudson terrace. *Sample 8*, Figure 6, is a very fine sand from the channel on the inside of a bend 6 miles below Alexandria. *Number 15* is a silty sand from a 9 foot depth of channel 16 miles below Alexandria. Fine and very fine sand was the most abundant material in the channel between Alexandria and Egg Bend. At that time the river was carrying a capacity load of silt and even a slight retardation of the current caused deposition of much red silt and clay.

Below Egg Bend the river follows a very winding course generally north and east between the Point Maigre and the Avoyelles

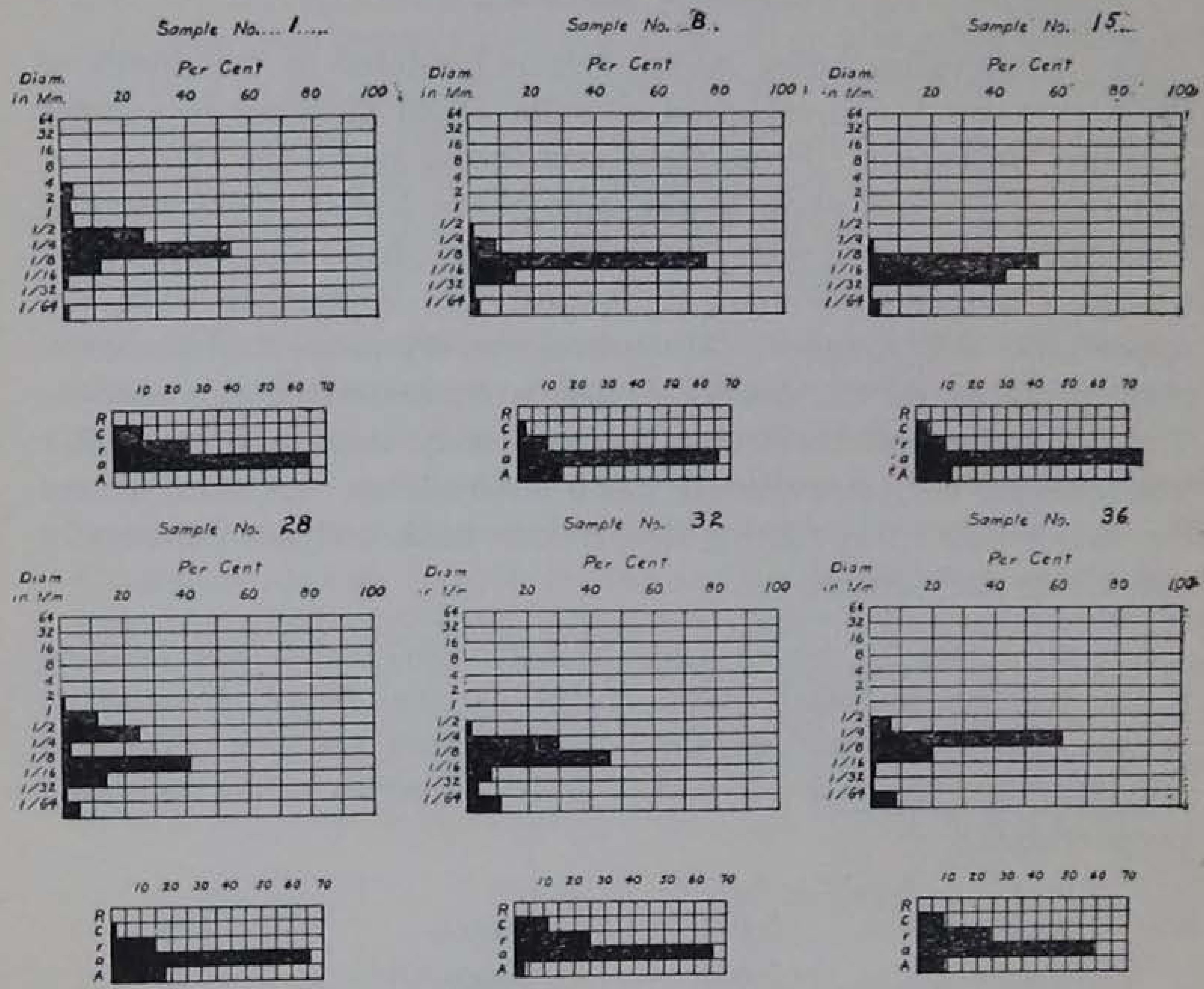

Figure 6. Analysis graphs of sediments from Red River between Alexandria and the mouth of Black River.

Locations of Samples Shown in Figure 6

No. 1—1/4 mile below Alexandria; midstream, depth 14 feet, current 4 m. p. h.

No. 8—6 miles below Alexandria; 50 feet off lower end of a bar at a bend, depth 4 feet, current 2 m. p. h.

No. 15—16 miles below Alexandria; from main channel 30 feet from right bank, depth 9 feet, current 1 1/2 m. p. h.

No. 28—33 miles below Egg Bend; 50 feet from right bank, depth 12 feet, current 1 1/2 m. p. h.

No. 32—From midstream in Black River 1 1/2 miles above its mouth; depth 30 feet, current 2 m. p. h.

No. 36—From midstream in Red River 2 1/2 miles below the junction with Black River, depth 30 feet, current 6 m. p. h.

Hills. According to Veatch[14] it was diverted from its old course to the southeast, the present course of Bayou Boeuf, by the log rafts which ponded the waters below Alexandria. The ponded waters found an outlet along the north side of the valley, and that course has been maintained since the destruction of the raft. For the lower 40 miles of its course the river flows generally northeastward on the swampy Mississippi River plain. Black River, largest tributary of the Red, joins it 24 miles above the mouth.

At the time the samples were taken from this part of the lower river, the water level was high enough to submerge the low banks at many places, and only 4 bars were seen above water below Egg Bend. The current was strong all across the stream in most places, and the water was very turbulent. Eddies were common, especially on the insides of bends. The heavy load of red silt colored the water so strongly that no light could be seen at a depth of 1 foot beneath the surface.

Sample 28 contains the coarsest material found in the river below the Avoyelles Hills, and the only one containing particles larger than 1/2 mm. in diameter. It was taken from the channel 33 miles below Egg Bend where the bottom was composed of firmly packed, ripple-marked sand. This material is represented by the lower half of the mechanical analysis graph. The coarser grains, 1/8 to 2 mm. in diameter, were being carried and shoved along on the hard-packed surface. *Number 32* is typical of the sediment in Black River channel near its mouth. In texture it resembles the fine channel sands of the main stream, but its color is gray instead of red or brown. The distant coarse grade is 90 per cent calcite, and wood fragments are numerous in all grades. Black River was contributing relatively small quantities of fine sand and silt, and its clear water presented a striking contrast to the brightly colored main stream. In heavy mineral content the Black River sediments near the mouth, except for a deficiency of iron oxides, are similar to those of Red River.

Sample 36, (fig. 6) from the main channel of Red River 2 1/2 miles below the confluence, contains 90 per cent frosted quartz grains in the major grade. The abundance of gray and black chert suggests the influence of the Black River sediments. The heavy

[14] Veatch, A. C.—Geology and Underground Water Resources of Northern Louisiana and Southern Arkansas: U. S. Geol. Survey, Prof. Paper 46, p. 63, 1906.

mineral content of the sands from below Egg Bend is higher on the average than those from other parts of the river. The average proportion is 2 per cent of the fine admixture.

Channel Sediments Taken at and Near the Confluence of Red, Old, and Atchafalaya Rivers

An unusual set of conditions exists at the mouth of Red River. Any one who has visited the region or has studied it is familiar with the fact that Red River does not flow into the Mississippi, but into the Atchafalaya when conditions are normal. At this point Red River water flowing south unites with the water of Old River, a west-flowing distributary of the Mississippi, to form Atchafalaya River which flows generally south to Atchafalaya Bay on the Gulf of Mexico. Thus all the Red River sediments are usually poured with its water into the Atchafalaya. When the Mississippi is at a very low stage and Red River is unusually high, the flow of water in Old River may be reversed; and Red River water and sediments are added to the Mississippi.

Several series of samples were taken across the channels of the three streams at various distances from their confluence. *Samples 245 and 184,* Figure 7, are typical sediments from Old River. *Number 245* contains the coarsest material that could be found in any of the channels. The two coarsest grades contain 75 per cent limestone fragments, some ferruginous nodules, and wood fragments. *Sample 184* is the normal type of channel sand from Old River 100 yards above the confluence. *Samples 174 and 242* are the coarsest and finest sediments from Red River channel 1/2 mile above its mouth. Sand grains up to 1/2 mm. in diameter are the largest grains that could be found in Red River near its mouth. Silts having a texture similar to that of *Number 169,* from the Atchafalaya 1/2 mile below the junction, are of common occurrence along the banks and in slower current deposits of the three streams. *Sample 170* was taken from the main channel of Atchafalaya River 1/2 mile below the junction.

The color of the sand grades in Red and Old Rivers is similar after elutriation and sieving. The finer particles of Red River sediments are red or red-brown, and those of Old River are gray. Therefore the color of sediments in the two streams depends largely on the coloring matter contained in the silts and clays which are in suspension and are mixed with the coarser silts and sands. Dur-

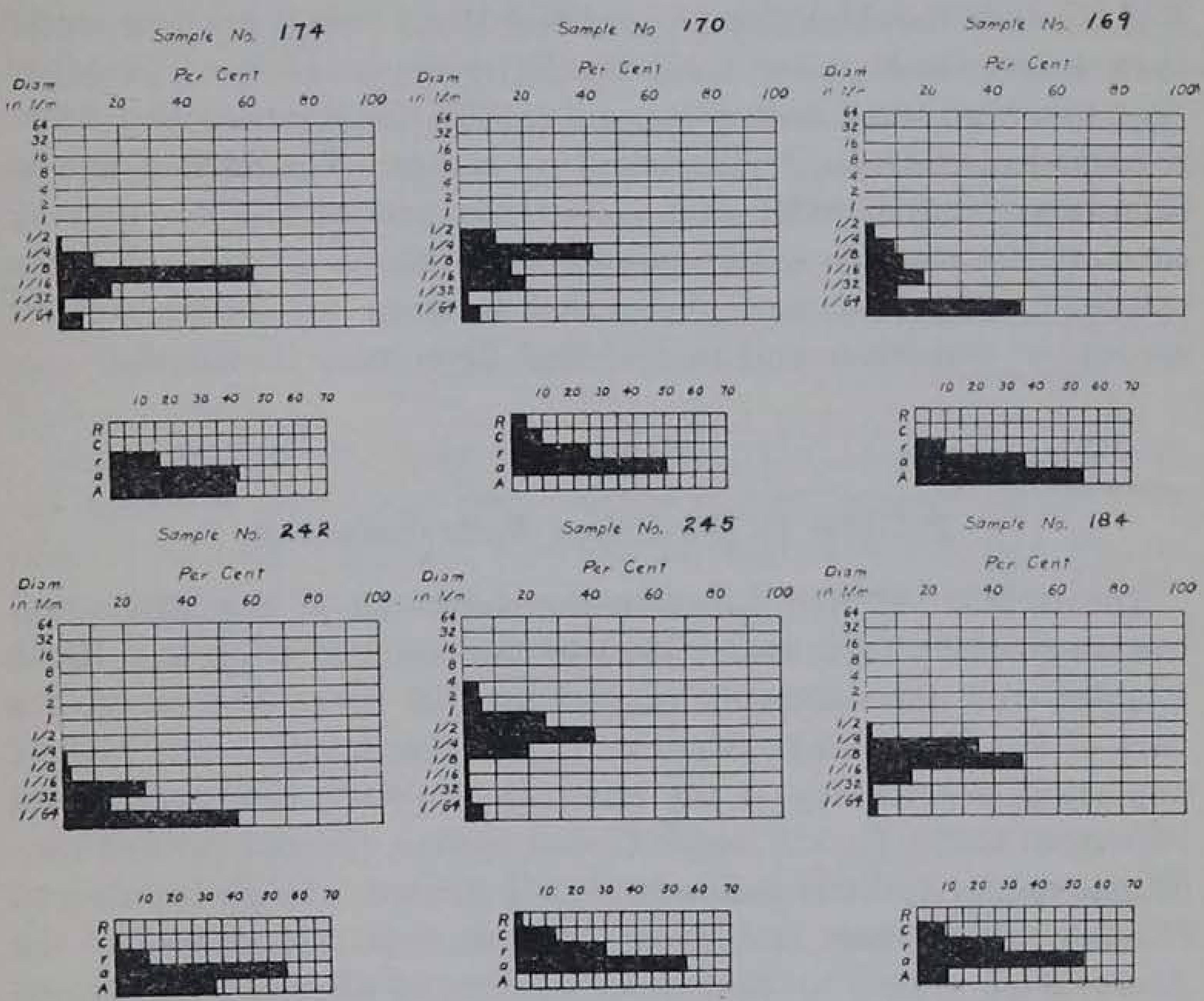

Figure 7. Analysis graphs of sediments obtained at and near the mouth of Red River.

Locations of Samples Shown in Figure 7

No. 174—1/2 mile above the mouth in Red River; 75 feet from left bank, depth 4 feet, current 2 m. p. h.

No. 170—From Atchafalaya River 1/2 mile below junction with Red and Old Rivers; midstream, depth 14 feet, current 2 1/2 m. p. h.

No. 169—From Atchafalaya River 1/2 mile below junction with Red and Old Rivers; 40 feet from right bank, depth 14 feet, current 2 m. p. h.

No. 242—From Red River 1 mile above the mouth; 60 feet from right bank, depth 12 feet, current 1 1/2 m. p. h.

No. 245—From Old River 3/4 mile above the mouth; midstream, depth 30 feet, current 4 m. p. h.

No. 184—From Old River 100 yards above the confluence with Red and Atchafalaya Rivers; 60 feet from left bank, depth 18 feet, current 3 1/2 m. p. h.

ing normal and low stages of water no pebbles are contributed by Red River to the Atchafalaya, and Old River brings nothing larger than 4 mm. in diameter from the Mississippi. If the Mississippi rises to a high stage as it did in July, 1928, the water in Red River is backed up for many miles above its mouth. The current is considerably reduced under such conditions, and contributes nothing coarser than medium sand while these conditions prevail. No conspicuous differences were discovered between the heavy mineral content of Old River and that of Red River near its mouth.

Summary

Relation to Mississippi Delta Sediments

The relation of Red River to the sediments of the Mississippi has been briefly explained. Most of the material from Red River mingles with the sediments carried by Old River and becomes a part of the Atchafalaya deposits. The Atchafalaya is the highest important distributary of the Mississippi system, and it forms an important outlet for the water of that system. Under present conditions relatively little sediment ever is carried into the Mississippi channel proper from Red River. The material contributed to the Atchafalaya system by Red River consists of dissolved salts, enormous quantities of red silts and clays, and sand grains up to a possible maximum of 1 mm. in diameter.

Sediment Types

Most of the sediments of Red River may be classified under 5 heads: *channel sands, chute deposits, muds, pudding sands, and lag materials.* The channel sands are far more abundant than all other types combined, and might be cited as the typical sediment of Red River. They are well sorted and contain relatively small amounts of silt. In many of them 80 to 90 per cent of the sample is contained in two size grades. *Samples 255, 263, 210, and 237* of Figure 2 are typical channel sands. They contain a few pebbles in some parts of the river, but no true gravels were found anywhere in the channel. The channel sands, therefore, represent the bulk of the coarse load of the river, and cover its bottom at most places in the main channel. The heavy mineral concentrates which occur in a few places might be included as a separate type, but their texture is that of sand. *Sample 68,* Figure 5, is an example.

The chute deposits are the silts or muds deposited by decreasing currents in the secondary channels. *Sample 159,* Figure 5, is a typical example, and has a high range of coarse grades.

The pudding sands are a rare type in Red River, and occur in the bank deposits or in the swiftest current of the main channel. The pebbles are predominantly clay, quartz, or chert. They represent a type of lag deposit in which the coarse pieces, pebbles up to 30 mm. in diameter, are incorporated in a coarse sand. The pebbles may be rolled or pushed along the bottom, but travel more slowly than the sands.

The muds are the finer materials deposited in slow current on the insides of bends, and wherever the current is much slower than that of the main channel. *Samples 90,* Figure 4, and *242,* Figure 7, are typical river muds. The maximum ingredient is the fine silt grade or the clay grade. The finer sediments are invariably deeper red in color because the iron oxides are concentrated chiefly in them. Thus they impart a bright color to the water, the bank sediments, and most of the sands.

Lag sedíments are a rare type in the river chiefly because the materials available are usually small enough to be transported by the current in the main channel. In a few places where pebbles are available a scouring action has removed adjacent finer grades to leave sediments showing a secondary maximum of pebble-size grains. This type is exemplified by *Samples 200 and 205,* Figure 3.

Sources of Sediments

The sediments in the river are influenced by very local sources, and the bulk of the coarse material travels a relatively short distance. This relationship was recognized at many places along the river, and only a small part of the evidence can be presented here. A few examples must suffice. The sediments in the region of the Catahoula sandstone bear a resemblance to that formation in the following characteristics: (1) abundant zircon, (2) unusually large percentage of well rounded and frosted quartz grains, (3) many pebbles derived from calcareous rosettes and nodules, (4) comparative uniformity of many fine channel sands, (5) the presence of pyrite.

The channel sediments in the region of the Wilcox formation show the following similarities to the country rock: (1) abundant lignite and woody material, (2) many pebbles and fragments of iron oxide, (3) great quantities of red silt.

In the region of the upper Cretaceous marls and chalks the river sediments are considerably finer on the average, and the color of the suspended silts and clays in that region modifies the typical red color of the water to brown or gray. The absence of pebbles in the lower 40 miles of the channel is proof that the coarse material occurs only near its sources.

Remnants of Organisms

Although the river contains many fish, shrimps, and clams, the shells and bones were rarely found in the channel sediments. The abundant gar-pike, which is a voracious scavenger, may be partly accountable for the destruction of other fish and shrimps. Abrasion by sand and pebbles under the influence of swift currents is also responsible for the disintegration of shells and bones before they can be preserved. The abundant vegetation of the region furnishes logs, stumps, and smaller fragments of wood to the river in many places.

Deposition and Erosion

Although the river has long been properly considered an old stream, it is actively eroding its channel in several places in Louisiana. A number of the obstructions now being cut away have resulted from channel changes occasioned by the great log rafts. The rapids at Alexandria and 8 miles above are typical of this situation. Erosion of tough clay strata is taking place at Coushatta and near Montgomery, Louisiana. In general Red River is a stream at or near grade, and is widening its flood plain by lateral planation, but exceptions such as those mentioned above are notable.

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